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EFFECT OF FERTILIZER TYPES ON SOIL CHEMICAL PROPERTIES, ROOT YIELD AND β-CAROTENE CONTENT OF ORANGE FLESHED SWEETPOTATO AT UMUDIKE, SOUTH-EAST NIGERIA

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Abstract
This study was conducted at the Research Farm of National Root Crops Research Institute (NRCRI) Umudike to evaluate the effect of composite manure and mineral fertilizer on soil chemical properties, root yield and β-Carotene content of orange fleshed sweetpotato. The experiment was a 5x4 factorial laid out in randomized complete design (RCBD). The treatment comprised of five levels of composite manure (Pig manure, cowdung and poultry manure) applied at the rate of 0, 2, 4, 6 and 8t/ha and mineral fertilizer (NPK 15:15:15) at 0, 200, 400 and 600kg/ha, and replicated three times. Data collected were subjected to analysis of variance (ANOVA) by the use of GENSTAT software package and treatment means separated using Fisher's Significant Different (LSD) at 5% level of probability. Results of the study showed that all the soil chemical properties studied were significantly ($p<0.05$) improved by application of composite manure. Application of mineral fertilizer singly, significantly improved available P, Exchangeable K, total N and percentage base saturation. The interaction of composite manure and mineral fertilizer significantly improved the organic matter, exchangeable calcium and effective cation exchange capacity of the soil relative to the control. Combined application of mineral fertilizer and composite manure significantly ($p<0.05$) increased the root yield of orange fleshed sweetpotato with application of 4t/ha composite manure + 400kg/ha mineral fertilizer, giving the highest total root yield of 15.90t/ha. The β-carotene content of the orange fleshed sweetpotato increased generally with increasing rate of the treatment combinations with application of 8t/ha composite manure + 200kg/ha mineral fertilizer giving the highest β-carotene content of 733.2μg/g. From the results obtained, application of 4t/ha composite manure + 400kg/ha mineral fertilizer is recommended for good root yield, while application of 8t/ha composite manure + 200kg/ha mineral fertilizer is recommended for farmers who wish to enhance the β-carotene content.

Keywords: Composite manure, mineral fertilizer, soil chemical properties, orange fleshed sweetpotato, and β-Carotene

Introduction

More than 80% of Sweetpotato farmers in Nigeria do not apply fertilizer or apply insufficient amounts, often citing high cost or non-availability of inorganic fertilizers (EPAR, 2012). The use of inorganic fertilizer alone in the Nigerian farming system has been found to be unsuitable (Obigbesan and Amalu, 1985). The concept of 'integrated nutrient management', utilizing all available organic and inorganic resources has become a dominant paradigm for improved or increased yields in small holder agricultural system of sub-Saharan Africa (SSA) to ensure both efficient and economic use of scarce nutrient resources (Vanlauwe *et al.,* 2001). Yeng *et al.* (2012) noted that the use of organic manure to supplement inorganic fertilizer as an integrated nutrient management strategy is of paramount importance towards reducing the cost of soil input, maximizing yields and sustaining sweetpotato and other crops. According to Nedunchezhiyan and Reddy (2002), sweetpotato assimilates nutrients throughout the growing period when there is integrated use of inorganic (immediately available) and organic (slow mineralization) source of nutrients which lead to higher yield attributes.

The high yielding orange fleshed sweetpotato varieties are fertilizer responsive (Nedunchezhiyan *et al.,* 2010). Applications of inorganic fertilizers have been reported to increase root yield but negates the quality of sweetpotato (Nedunchezhiyan and Reddy, 2002). Better sweetpotato root quality was observed at optimum amount of nitrogen supply, especially through organic sources (Nedunchezhiyan *et al.,* 2003). B-carotene content of the root though governed by the genetic factors, agronomic factors like source and quantity of nutrients significantly influenced the content (Nedunchezhiyan, *et al.,* 2010). There is limited information on the effect of integrated use of composite manure and mineral fertilizer on soil chemical properties, root yield and β- Carotene content of orange fleshed sweetpotato in South-East Nigeria and hence the need for this study.

Materials and Methods

The experiment was carried out at the Western Farm of NRCRI Umudike. Umudike is located on latitudes $05^{0}29^{'}$N and longitude $07^{0}33^{'}$E with an altitude of 122m above sea level. The experiment was a 5x4 factorial laid out in Randomized Complete Block Design (RCBD). The plot size measures 3m x 3m with 0.5m separating the plots, and 1m separating the replicates. Treatments for the experiment were cow dung, poultry manure, pig manure and mineral fertilizer (NPK 15:15:15). The cow dung and pig manure were sourced from the cattle and piggery units of Michael Okpara University of Agriculture Umudike, while the poultry droppings (battery cage) were sourced from the poultry unit of NRCRI, Umudike. NPK 15:15:15 fertilizer was sourced from the open market. Equal weights (72kg each) of the three animal manure sources were bulked together and applied to the plots at the rate of 2, 4, 6 and 8t/ha with 0t/ha as control. They were factorial combined with 0, 200, 400 and 600kg/ha of NPK 15:15:15, giving a total of 20 treatment combinations, replicated three times. The animal manures were applied to the plots one week before planting, while mineral fertilizer was applied at 4 weeks after planting. The test crop (orange fleshed sweetpotato variety, Umuspo 1) was obtained from the Sweetpotato Programme of NRCRI, Umudike. The sweetpotato vine cuttings (4 nodes) were planted on the crest of the ridges at a spacing of 30cm within rows and 1m between rows. The cuttings were planted 2 nodes down the soil and 2 nodes on the soil surface. All agronomic practices recommended for sweetpotato production were carried out. The storage roots were harvested at 16 weeks after planting and graded based on weights as marketable roots (>100g), unmarketable roots(<100g) (Levett,1993), and total root yield computed. Pre-planting and post planting soil samples were collected at the depth of 0-30cm. The samples were air dried, grinded and screened through a 2mm sieve and stored in the laboratory for analysis. Particle size distribution was determined using Bouyocous hydrometer method (Gee and Or, 2002) and texture determined using textural triangle (SSS, 2003). Soil pH was determined using glass electrode pH metre in the ratio of 1:2.5 (Thomas, 1996). Organic carbon was determined using wet oxidation method as described by Nelson and Somers (1996). Organic matter was estimated by multiplying % organic carbon by a factor of 1.724. Total Nitrogen was determined using microjedahl apparatus (Bremmer, 1996). Available phosphorous was determined according to the procedure of Olsen and Sommers (1982). Exchangeable bases were determined by Ammonium acetate leaching and exchangeable acidity by titration (Summer and Miller, 1996). Base saturation was also obtained (exchangeable bases/ECEC x 100).The effective cation exchange capacity (ECEC) was determined by summation of exchangeable bases and exchangeable acidity. The carotenoid analysis was estimated using the method described by Rodriguez-Amaya and Kimura (2004) and estimated using the formula:

$$\text{Total carotenoid } \mu g/g = \frac{A \times V\,ml \times 10^4 xDF}{A_{1cm}^{1\%} \times Pg}$$

Where:
A = Absorbance
V = Total volume of extract (ml)
P = Sample weight (g)

$A_{1cm}^{1\%}$ = 2592 (β-carotene Extinction Coefficient in petroleum ether)
DF = dilution factor and multiplied by 100 to get the carotenoid content in μg/100g

Statistical analysis of data generated was performed using Genstat Discovery Edition with the procedures of factorial experiments. Significant means were separated using Fishers least significant difference (F-LSD) at 5% level.

Results and Discussion

Properties of the Soil of Experimental Site

The physical and chemical properties of the soil before the application of the treatments are presented in Table 1. The soil was sandy loam in texture with pH value of 4.2 and low in most essential nutrients, indicating poor soil fertility and hence, the need for amendment for increased crop yield.

Table 1: Properties of the soil and experimental sites

Soil properties	Values
Sand (%)	79.60
Silt (%)	6.40
Clay (%)	14.00
Textural class	Sandy loam
Soil pH (H_20)	4.2
Organic matter (%)	1.79
Total nitrogen (%)	0.028
Available phosphorous(mg/kg)	10.6
Exchangeable acidity (Cmol/kg)	1.40
Calcium (Cmol/kg)	3.20
Potassium (Cmol/kg)	0.043
Magnesium (Cmol/kg)	0.80
Sodium (Cmol/kg)	0.092
ECEC (Cmol/kg)	5.54
Base saturation (Cmol/kg)	74.72

Table 2: Chemical properties of the composite manure used for the study

Chemical properties	Value
pH(H2O)	10.5
N (%)	5.39
P (%)	3.28
K (%	3.68
Ca (%)	2.67
Mg(%	1.95
Na (%)	2.33
OM (%)	5.17

Effect of Composite manure and Mineral Fertilizer on Soil Chemical properties (pH, OM, N, P, K)

The results of the effect of composite manure and mineral fertilizer on soil pH, N, P, and K showed that application of composite manure singly significantly ($p<0.05$) increased the pH, N, P, and K contents of the soil from 4.53-5.00, 0.0513-0.2007%, 14.57-29.90mg/kg and 0.0390-0.0753Cmol/kg respectively. Mineral fertilizer application also increased the N, P, and K content of the soil from 0.0513-0.0980%, 14.57-18.70mg/kg and 0.0390-0.0713Cmol/kg respectively. The interaction of the composite manure and mineral fertilizer significantly ($p<0.05$) increased organic matter content of the soil from (2.020-3.390%). The significant differences observed in the plots treated with composite manure confirmed the ability of organic wastes to increase soil pH, N, P, and K, thus creating a favourable medium for crop performance. Ano and Ubochi (2007) reported an increase in soil pH with the use of different animal manures. The increase in the organic matter contents of the soil might be attributed to direct incorporation and subsequent mineralization of organic matter in the soil which provides a good environment for decomposing microorganisms. Kimetu *et al.* (2004) reported that the use of organic amendments either singly or in combination with mineral fertilizers plays a significant role in sequestering carbon, and building up of soil fertility. The increase in total N due to the application of composite manure might be due to the greater multiplication of microbes caused by the addition of organic materials for the conversion of organically bound N to inorganic form. The increase in total N content observed in the plots treated with mineral fertilizer might be due to the direct addition of nitrogen through inorganic sources (mineral fertilizer) as reported by Ewulo *et al.* (2015). The appreciable build up in available P in plots treated with composite manure may be attributed to the influence of organic manure in increasing the available P in soil through complexing of cations like Fe^{2+} and Al^{3+} which are mainly responsible for the fixation of phosphorus. Zsolamey and Gorlitz (1994) reported that incorporation of manure and crop residues have been shown to increase the rate of desorption of P and thus improve the available P content of the soil. The increase in available P in the plots treated with mineral fertilizer may be due to direct addition of P from the mineral fertilizer as reported by Ewulo *et al.* (2015).The observed increase in the available K content of the composite manure treated plots may be ascribed to the reduction of fixation and release of K due to the interaction of organic matter with clay. Also the increase in K contents of the plots treated with mineral fertilizer may be attributed to the direct addition of potassium to the available K pool of the soil through the mineral fertilizer application as reported by Ewulo *et al.* (2015).

Table 3: Effect of composite manure and mineral fertilizer on soil pH

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	4.53	4.77	4.90	5.00	4.97	4.83
200	4.60	4.73	4.87	5.00	5.03	4.85
400	4.77	5.00	5.03	5.17	4.87	4.97
600	4.70	4.8	4.93	5.03	4.97	4.90
Mean	4.65	4.85	4.93	5.05	4.96	

LSD (0.05) Composite manure = 0.1743. LSD (0.05) NPK = N.S. LSD (0.05) Composite manure X NPK = N.S

Table 4: Effect of composite manure and mineral fertilizer on soil organic matter

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	2.020	2.660	2.767	3.023	3.300	2.755
200	2.090	2.080	2.627	2.863	2.983	2.529
400	2.880	2.130	2.910	3.160	3.390	2.894
600	3.160	1.430	2.290	2.773	2.967	2.524
Mean	2.539	2.075	2.648	2.955	3.160	

LSD (0.05) Composite manure = 0.2474. LSD (0.05) NPK = 0.2213. LSD (0.05) Composite manure X NPK = 0.4947

Table 5: Effect of composite manure and mineral fertilizer on soil total nitrogen

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	0.0513	0.1073	0.1358	0.1447	0.2007	0.1279
200	0.0467	0.0793	0.0980	0.1213	0.1447	0.0980
400	0.0560	0.1213	0.1213	0.1587	0.1867	0.1288
600	0.0980	0.1167	0.1167	0.1633	0.2053	0.1400
Mean	0.0630	0.1062	0.1178	0.1470	0.1843	

LSD (0.05) Composite manure = 0.02274. LSD (0.05) NPK =0.02034. LSD (0.05) Composite manure X NPK =N.S

Table 6: Effect of composite manure and mineral fertilizer on soil available phosphorous

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	14.57	17.07	21.10	22.23	29.90	20.97
200	15.63	19.57	26.77	31.20	37.33	26.10
400	17.00	23.43	25.27	29.37	38.40	26.69
600	18.70	29.87	36.73	41.00	43.93	34.05
Mean	16.48	22.48	27.47	30.95	37.39	

LSD (0.05) Composite manure = 3.999. LSD (0.05) NPK = 3.577. LSD (0.05) Composite manure X NPK =N.S

Table 7: Effect of composite manure and mineral fertilizer on exchangeable potassium

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	0.0390	0.0447	0.0510	0.0540	0.0753	0.0528
200	0.0437	0.0457	0.0503	0.0547	0.01053	0.0599
400	0.0513	0.0463	0.0530	0.0587	0.0717	0.0562
600	0.0713	0.0527	0.0640	0.0737	0.1323	0.0788
Mean	0.0513	0.0473	0.0546	0.0602	0.0962	

LSD (0.05) Composite manure = 0.1490. LSD (0.05) NPK = 0.01333. LSD (0.05) Composite manure X NPK

Ca, Mg, Na, ECEC, %BS, EA

Combined application of composite manure and mineral fertilizer significantly ($P<0.05$)) improved the Ca, ECEC and EA content of the soil relative to control from 2.533-4.667Cmol/kg, 5.107-7.600Cmol/kg and1.3830.430Cmol/kg respectively. Application of composite manure singly significantly increased the Mg, Na and %BS content of the soil from 1.067-2.400Cmol/kg, 0.093 -0.1497Cmol/kg and 72.78-89.55% respectively. The observed improvements in the Ca, and ECEC contents of the soil might be attributed to the better buffer capacity of the soil as a result of the composite manure application and the rise in organic matter content, which increased the net negative charges in the exchange complex. Also, the reduction in the exchangeable acidity content of the plots amended with composite manure and mineral fertilizer may be due to the improvement in soil pH and lowering of Al^{3+} and Fe^{2+} concentration in the soil by the composite manure. Similar results were reported by Mutegi *et al.* (2012) and Magagula *et al.* (2010). The increase in the Mg, Na and % BS contents of the soil following the application of composite manure could be attributed to the improvement in soil pH which has a positive relationship with the availability of basic cations like magnesium and sodium. Mucheru *et al.* (2007) noted that increasing the pH of acidic soils through organic amendments improves the plant availability of macronutrients such Mg and Na, while reducing the solubility of elements such as Al and Mn.

Table 8: Effect of composite manure and mineral fertilizer on exchangeable calcium

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	2.533	3.067	3.467	3.600	4.267	3.387
200	2.533	3.200	3.600	4.267	4.667	3.653
400	3.200	2.533	2.933	3.600	4.133	3.280
600	4.000	2.400	3.200	4.267	4.000	3.467
Mean	3.067	2.800	3.300	3.800	4.267	

LSD (0.05) Composite manure = 0.4458. LSD (0.05) NPK = N.S. LSD (0.05) Composite manure X NPK =0.8916

Table 9: Effect of composite manure and mineral fertilizer on exchangeable magnesium

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	1.067	1.333	1.600	1.867	2.400	1.653
200	0.933	0.933	1.467	1.733	2.133	1.440
400	1.333	0.933	1.733	2.133	2.667	1.760
600	1.600	0.933	1.467	2.000	2.400	1.680
Mean	1.233	1.033	1.567	1.933	2.400	

LSD (0.05) Composite manure = 0.3043. LSD (0.05) NPK = N.S. LSD (0.05) Composite manure X NPK =N.S

Table 10: Effect of composite manure and mineral fertilizer on exchangeable sodium

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	0.0937	0.1013	0.1203	0.1350	0.1673	0.1235
200	0.1013	0.0910	0.1100	0.1203	0.1527	0.1151
400	0.1130	0.0983	0.1010	0.1230	0.1583	0.1187
600	0.1170	0.1073	0.1347	0.1497	0.1773	0.1437
Mean	0.1144	0.0995	0.1165	0.1320	0.1639	

LSD (0.05) Composite manure = 0.01548. LSD (0.05) NPK = NS. LSD (0.05) Composite manure X NPK =N.S

Table 11: Effect of composite manure and mineral fertilizer on soil exchangeable acidity

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	1.383	1.053	0.970	0.847	0.807	1.012
200	0.933	0.933	0.853	0.673	0.540	0.797
400	0.880	0.770	0.560	0.533	0.430	0.635
600	0.800	0.833	0.693	0.547	0.440	0.663
Mean	1.012	0.897	0.769	0.650	0.554	

LSD (0.05) Composite manure = 0.0650. LSD (0.05) NPK = 0.0581. LSD (0.05) Composite manure X NPK =0.1300

Table 12: Effect of composite manure and mineral fertilizer on effective cation exchange capacity

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	5.107	5.600	6.210	6.500	7.717	6.227
200	4.597	5.200	6.083	6.850	7.600	6.066
400	5.580	4.383	5.287	6.450	7.460	5.832
600	6.620	4.327	5.560	6.503	7.163	6.035
Mean	5.476	4.877	5.785	6.576	7.485	

LSD (0.05) Composite manure = 0.4271. LSD (0.05) NPK =N.S. LSD (0.05) Composite manure X NPK =0.8542

Table 13: Effect of composite manure and mineral fertilizer on percentage base saturation

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	72.78	80.97	84.30	86.96	89.55	82.91
200	77.65	81.30	85.69	91.73	92.85	85.84
400	84.11	82.29	89.16	91.65	94.22	88.29
600	87.92	86.76	87.52	88.22	93.79	88.84
Mean	80.61	82.83	86.67	89.64	92.60	

LSD (0.05) Composite manure = 2.608. LSD (0.05) NPK =2.333. LSD (0.05) Composite manure X NPK =N.S

Effect of Composite manure and Mineral fertilizer on the Root yield of Orange fleshed Sweetpotato

The interaction of composite manure and mineral fertilizer significantly ($p<0.05$) increased the total root yield of orange fleshed sweetpotato relative to the control. The highest mean root yield of 15.90t/ha was recorded with the application of 4t/ha organic manure + 400kg NPK. The higher root yield obtained with the application of composite manure and mineral fertilizer in this study might be as a result of improvement in the physicochemical properties of the soil which led to the release of nutrients for crop uptake. Similar results were reported by Agyarkor *et al.* (2014) with incorporation of organic manure and NPK on sweetpotato yield; Asawalam and Onwudiwe (2011) with complementary use of cow dung and mineral fertilizer on sweetpotato; Yeng *et al.* (2012) with integrated application of chicken manure and inorganic fertilizer on growth and yield of sweetpotato.

Table 12: Effect of composite manure and mineral fertilizer on total root yield of orange fleshed sweetpotato (t/ha)

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	7.83	11.37	13.17	11.67	10.70	10.93
200	8.30	12.07	13.13	12.37	12.27	11.63
400	11.53	13.73	15.90	9.93	12.00	12.62
600	14.93	10.47	9.13	13.13	14.83	12.50
Mean	10.65	11.91	12.83	11.78	12.45	

LSD (0.05) Composite manure = N.S. LSD (0.05) NPK =N.S. LSD (0.05) Composite manure X NPK =4.387

Effects of Composite Manure and Mineral Fertilizer on the-β carotene content of orange fleshed sweetpotato

Application of composite manure singly and in combination with mineral fertilizer significantly ($p<0.05$) increased the β-carotene content of orange fleshed sweetpotato relative to the control. The highest β-carotene content of 733.2ug/100g was obtained with the application of 200kg/ha NPK + 8t/ha composite manure. Application of composite manure singly at 8t/ha gave β-carotenoid content of 726.6ug/100g. The increase in β-carotene content might be due to increased soil fertilization. Similar results were reported by Gichuhi *et al.* (2013), with application of different rates of broiler litter on Beauregard sweetpotato; Moumouni *et al.* (2013), with application of organic and mineral fertilizers on antioxidants, polyphenolic and carotenoid contents of orange fleshed sweetpotato; Neduchezhiyan *et al.* (2010), with application of farmyard manure in sweet potato; Kipkosgei *et al.* (2003), working with black night shade observed that β-carotene content was significantly increased depending on the type and the level of fertilizer applied. Nedunchezhiyan *et al.* (2010) noted that β-carotene content though governed by the genetic factor, agronomic factors like source and quantity of nutrients significantly influenced the content. Also the increase in the carotenoid content of the orange fleshed sweetpotato might be as a result of improvements in the total nitrogen contents of the soil. Ukom *et al.* (2009) reported that N fertilizer application significantly increased the carotenoid and crude protein content of sweetpotato with increasing N application up to 120 kg/ha. This indicates that nitrogen stimulates carotene biosynthesis as reported by Voswai *et al.* (2015) and thus agreeing with the findings of Constantin *et al,* (1984) and Ukom *et al.* (2011).

Table 14: Effect of composite manure and mineral fertilizer on the carotenoid content of orange fleshed sweetpotato (µg/100g)

	Composite Manure(t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	566.9	619.4	636.0	696.6	726.6	649.1
200	468.5	583.9	656.8	702.2	733.2	628.9
400	595.6	519.4	612.1	679.0	705.0	622.2
600	639.8	490.8	602.6	628.5	681.1	608.6
Mean	567.7	553.4	626.9	676.6	711.5	

LSD (0.05) Composite manure = 37.89. LSD (0.05) NPK = N.S. LSD (0.05) Composite manure X NPK = 75.78

Conclusion

This study showed that integrated nutrient management (combining organic and mineral fertilizers) holds the key to improving soil chemical properties, root yield and the β-carotene content of orange fleshed sweetpotato in a tropicl ultisol of South-East Nigeria. Composite manure and mineral fertilizer application improved most of the soil chemical properties studied. Combined application of composite manure and mineral fertilizer significantly ($p<0.05$) increased both the total and marketable root yield of orange fleshed sweetpotato. Composite manure and its combination with mineral fertilizer significantly increased the β-carotene content with application of 8t/ha composite manure + 200kg/ha NPK, giving the highest carotenoid content of 733.2µg/g. The carotenoid content of the orange fleshed sweetpotato increased generally with increasing rate of the treatments especially with composite manure, indicating that the carotenoid content of orange fleshed sweetpotato can be enhanced with organic manure sources. Therefore, orange fleshed sweetpotato production in the study area can be improved by combining the available animal manure sources such as cow dung, swine waste and poultry manure with mineral fertilizer. Application of 4t/ha composite manure + 400kg/ha NPK or 4t/ha composite manure is recommended for good root yield of orange fleshed sweetpotato in. For enhanced carotenoid content application of 8t/ha composite manure +200kg/ha mineral fertilizer or 6t/ha composite manure is recommended.

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